Name: Answer Key Period: ________ Date: ________

Honors Final Review

Part I: Define/explain the following terms/concepts.

1. Newton's Universal Law of Gravitation → F_g is proportional to the product of the masses and inversely proportional to the square of the distance between them
2. "Weightlessness" in orbit → in orbit you feel weightless since you are in constant free fall about the planet.
3. Work → work is done when a ① force ② causes a ③ displacement. $W = F\Delta x\cos\theta$
4. Power → The rate at which work is done. $P = W/t$
5. Force vs. Displacement Graphs → The area under the curve is the work done by the force
6. Energy → The ability to do work
7. Kinetic Energy → The energy of an object in motion
8. Potential Energy → The energy of an object due to its vertical position
9. Work-Energy Theorem → The work done equals an objects change in KE. $W = \Delta KE$
10. Law of conservation of energy → Energy can be transformed from one kind to another, but the total energy never changes.
11. Momentum (definition and units) → The product of mass and velocity; $kg\,m/s$ or $N\cdot s$
12. Law of conservation of momentum → momentum is always conserved in a closed, isolated system (no external forces)
13. Impulse (definition and units) → $\vec{J} = \vec{F}\cdot t = \Delta\vec{p}$; Units are the same as momentum
14. Center of mass → $X_{cm} = \frac{1}{M}\sum_i x_i m_i$; You do not need mass at the C.O.M.
15. Inelastic Collisions → KE is NOT conserved; In a perfectly elastic collision the objects stick together.
16. Elastic Collisions → No loss of KE; objects bounce off one another
17. Force vs Time Graphs → Area under curve is the impulse or Δp
18. Angular displacement → $\Delta\theta = s/r$
19. Angular velocity → $\omega = \Delta\theta/\Delta t$
20. Angular acceleration → $\alpha = \Delta\omega/\Delta t$
21. Torque → torque is analogous to force; $\tau = I\alpha = rF\sin\theta$
22. Moment of Intertia → analogous to mass; an objects resistance to a change in rotation
23. Newton's Second Law for Rotation → $\Sigma\tau = I\alpha$

*NOTE! Be careful with units in rotation problems. Formulas typically require radians.

Part II: Solve the following problems.

1. The radius of the earth is approximately 6.38×10^6m and the mass is approximately 5.97×10^{24}kg. What is the acceleration due to gravity at a height of 8.5×10^6m?

$F_g = mg = G\frac{m m_2}{r^2}$ ← Total distance from center of earth.

$g = 6.67\times10^{-11}\left(\frac{5.97\times10^{24}}{(6.38\times10^6 + 8.5\times10^6)^2}\right) = 1.798\ m/s^2$

2. Calculate the gravitational force exerted on a 3500 kg satellite orbiting 10,000km from earth (mass 5.97×10^{24}kg).

$F_g = G\frac{m_1 m_2}{r^2} = 6.67\times10^{-11}\left(\frac{3500(5.97\times10^{24})}{(10{,}000{,}000 + 6.38\times10^6)^2}\right)$

$F_g = 5194.46N$

3. Calculate the amount of work required to raise a 10kg object 3 m above the ground.

$W = F\Delta x \cos\theta$

$= mg\Delta x\cos\theta$

$= 10(9.8)(3)\cos 0 \Rightarrow W = 294J$

4. Calculate the amount of work required to stop a 25 kg object traveling at 8m/s.

$W = \Delta KE$

$= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$

$= \frac{1}{2}(25)(0^2) - \frac{1}{2}(25)(8)^2 \rightarrow W = -800J$

5. A 5kg cannon ball traveling 30 m/s creates a crater 2 m deep. What is the average force exerted by the cannon ball on the ground?

$W = \Delta KE = F\Delta x\cos\theta$

$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = F\Delta x\cos\theta$

$-\frac{1}{2}(5)(30)^2 = F(2)\cos 180°$

Ground exerts an upwards force while the displacement is down so $\theta = 180°$

$F = 1125N$

6. A box sliding on a frictionless surface at 15 m/s encounters a hill. How far up the hill will it slide?

$KE_i = PE_f$

$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$

$\frac{1}{2}(15)^2 = 9.8h \rightarrow$ $\boxed{h = 11.47m}$

7. A disk with a diameter of 15 cm is rolling at 15 m/s encounters a hill. How far up the hill will it slide?

$KE_T + KE_R = PE_f$

$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$

$\frac{1}{2}\cancel{m}v^2 + \frac{1}{2}\left(\frac{1}{2}\cancel{m}\cancel{r^2}\right)\left(\frac{v^2}{\cancel{r^2}}\right) = \cancel{m}gh$

$\frac{1}{2}(15)^2 + \frac{1}{4}(15)^2 = 9.8h \rightarrow$ $\boxed{h = 17.219m}$

☆ 8. An object is launched off a 20m tall ledge with an initial velocity of 5 m/s. What is the speed of the object upon impact?

$PE_i + KE_i = KE_f$

$\cancel{m}gh + \frac{1}{2}\cancel{m}v^2 = \frac{1}{2}\cancel{m}v^2$

$9.8(20) + \frac{1}{2}(5)^2 = \frac{1}{2}v^2 \rightarrow$ $\boxed{v = 20.42 m/s}$

9. A car traveling 10 m/s collides with an equal mass car at rest. If the cars stick together after the collision, what is the final speed they will travel?

$\vec{P_i} = \vec{P_f}$

$m_1v_1 = (m_1 + m_2)v'$

$\cancel{m}v_1 = 2\cancel{m}v' \rightarrow$ $\boxed{v' = 5 m/s}$

10. A cat jumps on a skateboard traveling at 15 m/s. If the mass of the cat and skateboard is 35 kg and they travel at 10 m/s, what is the mass of the cat?

$\vec{P_i} = \vec{P_f}$

$\cancel{m_cv_c}^{0} + m_sv_s = (m_c + m_s)v'$

$m_s(15) = 35(10)$

$m_s = 23.33kg$

$35 = m_c + m_s$

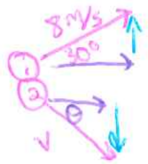
$35 = m_c + 23.33$

$\boxed{m_c = 11.66 kg}$

11. A pool ball traveling 10 m/s collides head on with a pool ball at rest. If they have the same mass and the first ball travels at 8 m/s at a 30 degree angle above the horizontal, how fast and in what direction does the second ball travel?

initial: ① → 10 m/s ②

final:



Y direction: $p_i = p_f$

$0 = m_1 v_{1y} + m_2 v_{2y}$

$v_{1y} = -v_{2y}$

$8 \sin 30 = -v_{2y}$

$v_{2y} = 4\,m/s\,\hat{y}$

X Direction: $m_1 v_1 = m_1 v_{1x} + m_2 v_{2x}$

$10 = 8\cos 30 + v_{2x}$

$v_{2x} = 3.07\,m/s$

$v = \sqrt{3.07^2 + 4^2} = \boxed{5.043\,m/s}$

$\theta = \tan^{-1}(4/3.07) = \boxed{52.48°}$

12. Is the situation described in number 11 a perfectly elastic collision?

initial KE: $\frac{1}{2}mv^2 = \frac{1}{2}m(10)^2 = 50m\ J$

final KE: $\frac{1}{2}mv^2 + \frac{1}{2}mv^2 = \frac{1}{2}m(8)^2 + \frac{1}{2}m(5.043)^2 = 44.7m\ J$

Since KE is lost, it is **NOT** a perfectly elastic collision.

13. A wheel rotates at 1500 rpm. What is its angular velocity in radians per second?

$\frac{1500\ rot}{min} \times \frac{1\ min}{60\ sec} \times \frac{2\pi\ rad}{1\ rot} = \boxed{157.08\ rad/sec}$

14. A record player is turned on from rest and accelerates at 1.23 rad/s². What is its speed after 2.8 seconds in rpm?

$\omega_i = 0\ rad/sec$

$\alpha = 1.23\ rad/s^2$

$t = 2.8\ sec$

$\omega_f = \omega_i + \alpha t$

$= 0 + 1.23(2.8)$

$\omega_f = 3.444\ rad/s \times \frac{60\ sec}{1\ min} \times \frac{1\ rot}{2\pi\ rad} = \boxed{32.88\ rpm}$

15. A 25 kg disk with radius .5m is initially spinning with a constant angular speed of 4 rad/s. The angular speed is then increased to 8 rad/s in 5 seconds. Find the angular acceleration, the moment of inertia and the torque of the disk.

$m = 25\ kg$

$r = .5\ m$

$\omega_i = 4\ rad/s$

$\omega_f = 8\ rad/s$

$t = 5\ sec$

$\alpha = \frac{\Delta\omega}{\Delta t} = \boxed{\frac{4}{5}\ rad/s^2}$

$I = \frac{1}{2}mr^2 = \frac{1}{2}(25)(.5)^2 = \boxed{3.125\ kg\,m^2}$

$\tau = I\alpha = 3.125(4/5) = \boxed{2.5\ N \cdot m}$